

MICROMETEOROIDS AND DEBRIS

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SCOPE

- WHAT MATERIALS ARE VULNERABLE?
 - ALL VULNERABLE TO HYPERVELOCITY IMPACTS
 - IMPORTANCE OF IMPACT EFFECT DEPENDS ON FUNCTION OF MATERIAL:
 - = MIRROR (EROSION)
 - = PRESSURE VESSEL (EXPLOSION)
- LEO MOST SIGNIFICANT REGION RELATIVE TO ORBITAL DEBRIS
 - METEOROID ENVIRONMENT INDEPENDENT OF ORBIT
 - RELATIVE VELOCITIES DEBRIS IN GEO ARE LOW
- CONSEQUENCES OF ENVIRONMENT EFFECT
 - SMALL SIZES-DEGRADATION
 - LARGE SIZES-CATASTROPHE

CORRELATION BETWEEN LAB/THEORY AND ACTUAL EFFECTS

- HYPERVELOCITY IMPACT MEASUREMENTS SIMULATE DEBRIS IMPACTS
 - SMALL PARTICLES (< 100 MM) TO 10'S KM/SEC
 - LARGE PARTICLES LIMITED TO 7-8 KM/SEC
- CANNOT SIMULATE MICROMETEOROID IMPACTS VERY WELL
 - VELOCITIES TO 40 KM/SEC
 - LOW DENSITY PARTICLES
- MASSIVE COLLISIONS CAN BE SCALED AND MODELED
 - MAJOR EFFECTS PREDICTED
 - SIZE AND VELOCITY DISTRIBUTION OF SMALL PARTICLES NOT WELL KNOWN

RELATED TOPICS

- STUDY OF IMPACTS/COLLISIONS IN SPACE
 - GROUND-BASED, SPACE-BASED (IF POSSIBLE) OBSERVATIONS - SIZE AND VELOCITY OF DEBRIS
 - "MISSIONS OF OPPORTUNITY"
- MITIGATION MEASURES
 - SWEEPING SMALL DEBRIS
 - AVOIDANCE MANEUVERS
 - MOVABLE SHIELD
 - REMOVAL OF LARGE OBJECTS
 - IMPROVED SPACECRAFT PAINT
 - OPERATIONAL PROCEDURES TO MINIMIZE BREAKUPS

FLIGHT EXPERIMENT POSSIBILITIES

ENVIRONMENT DEFINITION

- NON-RETRIEVABLE SATELLITES (SOURCE ID DIFFICULT)
 - 1 MM AND LARGER-QUICKSAT (\$100M)
 - BELOW 1 MM
 - = OFF-THE-SHELF SENSORS
 - = EXISTING/PLANNED EXPERIMENTS (SERTS, EOIM)
- RETRIEVABLE SATELLITES (SOURCE ID POSSIBLE)
 - LDEF RECOVERY
 - FREE-FLYER "GAS-CAN"
 - = EXPANDABLE SURFACES FOR LARGE AREA
 - = REGULAR LAUNCHES (2-3 YEAR INTERVALS)
- COSMIC DUST FACILITY FOR SPACE STATION
 - > 10 YEARS AWAY

SPACE EXPERIMENT REQUIREMENTS

- ENVIRONMENT FOR SIZES BELOW 10 CM POORLY DEFINED
 - UNCERTAINTY FACTORS OF 3 TO 10 FOR DEBRIS
 - RAPID CHANGES OF DEBRIS POPULATION ARE POSSIBLE (AND LIKELY)
 - METEOROID ENVIRONMENT DEFINED WELL ENOUGH
- SYNERGISM AND CUMULATIVE EFFECTS NOT WHOLLY PREDICTABLE, AND HENCE MAY NOT ALL BE SIMULATABLE. FLIGHT EXPERIMENT EXERCISES ALL POSSIBILITIES
- CANNOT COMPLETELY SIMULATE/CALCULATE EFFECTS OF MASSIVE COLLISIONS IN SPACE

SYNERGISTIC EFFECTS

- MANY POSSIBILITIES-RELATIVE IMPORTANCE UNKNOWN
- EXAMPLES
 - ATOMIC OXYGEN EROSION INITIATED BY IMPACT
 - CONTAMINATION INDUCED BY VAPOR FROM IMPACT
 - SPACECRAFT CHARGING EFFECTS FACILITATED BY PENETRATIONS
 - THERMAL EFFECTS PRODUCED BY EROSION OF THERMAL CONTROL COATINGS
- CASCADES CONCEIVABLE

CONFIDENCE LEVEL

- CAN WE BUILD SATELLITES FOR 10-30 YEAR OPERATION?
 - NO FOR LARGE AREA, LONG LIFE SATELLITES
 - = DEBRIS ENVIRONMENT NOT WELL ENOUGH KNOWN
 - NO FOR SATELLITES WITH NEW FUNCTIONS
 - = DON'T KNOW SYNERGISTIC EFFECTS AND THEIR IMPORTANCE
 - YES FOR SATELLITES OF CONVENTIONAL DESIGN AND FUNCTION

FLIGHT EXPERIMENTS NEEDED

- FIRST PRIORITY: MEASURE LEO ENVIRONMENT FOR SIZES BELOW 1 CM (GROUND-BASED RADARS TO COVER > 1 CM OBJECTS)
 - VITAL DATA FOR DETERMINING SIGNIFICANCE
- SECOND PRIORITY: REPEAT THE MEASUREMENTS AT INTERVALS TO MONITOR CHANGES
- THIRD PRIORITY: ESTABLISH NATURE AND SIGNIFICANCE OF POSSIBLE SYNERGISTIC EFFECTS
- FOURTH PRIORITY: UNDERSTAND DETAILS OF MASSIVE COLLISIONS IN ORBITS (BETTER DEFINITION OF ENVIRONMENT)

FLIGHT EXPERIMENT POSSIBILITIES

SYNERGISM/ACCUMULATED EFFECTS

- NEED LONG-TERM EXPOSURE OF REAL SYSTEMS
- RECOVERY OF OLD SATELLITES FOLLOWED BY DETAILED INTERDISCIPLINARY ANALYSIS
 - LDEF ~ 5 YEARS OLD, CAPTURE PLANNED NOVEMBER 1989
 - SMM, SAGE ~ 10 YEARS OLD
 - = CAPTURE BY SHUTTLE
 - TIROS ~ 30 YEARS
 - = CAPTURE USING ELV
- COSTLY, DIFFICULT TO RETRIEVE SATELLITES
 - NEED INTERDISCIPLINARY JUSTIFICATION
- LDEF REMAINS PRIME CANDIDATE FOR RECOVERY
 - MAJOR SOURCE OF NEW DATA